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PREDICTING NIF CARRYOVER
AT
PUBLIC WORKS CENTERS

by

David Leon Ricks

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Thesis Advisor: Joseph San Miguel

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PREDICTING NIF CARRYOVER AT PUBLIC WORKS CENTERS

by

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requirements for the degree of

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ABSTRACT

The scope of this research was the development of a statistical model for forecasting fund carryover for a Navy Public Works Center. The model was developed using monthly historical data from FY 85 to FY 88 for the following variables: (1) funds received; (2) billings; (3) backlog; (4) work in place; (5) and carryover. Simple, multiple and stepwise regression methods were applied. Also, an examination was performed on whether there might be a lagged relationship between the dependent and independent variables. This model can reliably forecast only up to three months in advance.

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I. INTRODUCTION

A. RESEARCH OBJECTIVES

The scope of this research is the development of a statistical model for forecasting fund carryover. The hypothesis is that fund carryover is functionally related to backlog of work. This model would forecast carryover four to six months in advance. The use of this model can become a management tool for the Public Works Center (PWC). A PWC is a Navy activity that provides a variety of services for its customers (i.e., maintenance repair, utilities, design, etc.). If the forecast shows that the PWC would be way short of the goal the PWC manager would ask his customers to submit more projects. On the other hand, if the forecast shows carryover to be over target, the manager would implement steps to speed up work in process.

The four to six month projection will allow the PWC manager sufficient time to set in motion changes that will minimize the impact to the customer while at the same time improving the PWC fund carryover situation.

B. BACKGROUND

The Navy has several activities that operate under the Navy Industrial Fund (NIF) concept and one of these is the PWC. The general idea of the NIF concept is for the PWC to operate like a business contractor. One of the significant differences is that the profit objective for the PWC is zero. The customer has to pay for all costs incurred for the services requested. The PWC uses the revenue from its customers to fully sustain the year round operations of the PWC, thereby replacing the need for yearly appropriations from Congress.

The primary NIF customers are governmental agencies who are funded annually with O&MN (Operations and Maintenance Navy). The yearly cycle of operations between the PWC and their customer is the following:

1. The PWC sets the rates that it will charge its customers three years in advance.
2. The customer prepares and submits, for approval, a yearly maintenance budget up their chain of command.
3. Congress appropriates funds for maintenance based upon the PWC rates.
4. The customer receives a yearly budget and then requests services from the PWC.

5. The PWC performs the service and then bills the customer.

PWCs never accomplish all the work they receive from their customers within the same fiscal year the work was requested. The amount of work that does not get completed is called **fund carryover**. In the business community fund carryover is analogous to advance orders from customers (i.e., backlog) in which no money changes hands, but the customer has committed to purchase the product at a later date.

A large fund carryover is something a business would like to have, because it means that it has backlog of work to keep the employees constantly working at full capacity. However, in today's budgetary environment large fund carryover has a detrimental effect for the NIF. The Department of Defense (DOD) budget experienced considerable growth in the early 1980's, however, the fiscal climate since 1985 has since changed. The federal government's budget deficit has been rising at an alarming rate since 1980. Congress's concern for this deficit was translated into the passage of the Gramm-Rudman-Hollings bill in 1985.

This bill compels Congress to make five yearly sequential across-the-board reductions in federal spending until the deficit has been reduced to zero. [Ref. 1:p. 276]

The two widely discussed methods to reduce the federal budget deficit are to raise federal income taxes and to reduce spending. Implementing a major federal income tax increase has not been undertaken by Congress, because of resistance by President Reagan and political reasons. The only tool Congress has is to reduce spending. However, certain portions of the federal budget will receive little or no cuts. These excluded areas comprise over 70% of the federal budget. The net result is that the remaining 30% of the federal budget--of which two-thirds is defense spending and one-third is domestic program--would bear almost all of any major cuts. [Ref. 1:pp. 239-240]

The tighter scrutiny by Congress of the DOD budget has forced the Office of the Secretary of Defense (OSD) to look at areas such as fund carryover for dollar savings. The NIF activity and the NIF customer are both part of the DOD budget so a high fund carryover is an indication of O&MN dollars that were not effectively utilized.

An additional view is that the NIF customer uses the NIF activity, such as a PWC, as a bank. That is, the customer

obligates dollars on vague projects near the end of the fiscal year and then later changes the scope of the project to fit real needs. This allows the NIF customer to reach their yearly obligational targets even though all the requirements for these dollars may not be valid.

OSD perceives the fund carryover amounts as not well-spent obligated dollars by PWC customers, in the year appropriated, that can be used in other portions of the DOD budget. The fund carryover is the cumulative total of prior years' backlog. If the NIF activities do not reduce their annual backlog, the carryover grows continuously. The Comptroller of the Navy (NAVCOMPT) was compelled to seriously take notice of carryover when OSD reduced the Navy Research and Development program by almost $2 billion in 1985 and over $1 billion in 1986, based on large NIF carryover amounts [Ref. 2].

Some of the reasons for PWC fund carryover are: (1) PWC manpower constraints; (2) customers submitting large dollar projects late in the fiscal year; and (3) delays in acquiring material for jobs. [Ref. 3] The PWCs have historically operated with a fund carryover and the amount

of that carryover was not a major concern of NAVCOMPT in the past.

The yearly amount of fund carryover that a PWC NIF activity can have is a predetermined goal that is negotiated between the individual PWC activity, NAVCOMPT and the Commander Naval Facilities Engineering Command (NAVFAC). Some of the criteria used in setting the goal is: (1) the current amount of backlog at the activity; and (2) the target carryover for the total NIF account. The PWC's problem is trying to accurately reach that goal. The PWC does not want to be too much over or under the goal.

The amount by which the PWC exceeds the goal impacts the other NIF activities and the overall NIF account. In order for the total NIF fund carryover to meet its goal another NIF activity has to come under its goal. If the PWC falls way short of the goal the PWC runs the risk of having their carryover goal reduced. This will diminish their flexibility (contract versus in-house) to accomplish work.

The PWC manager has an interesting dilemma. The PWC is being tasked to reduce fund carryover but at the same time it cannot refuse funds from the customer. So there is difficulty in translating the carryover target into

operational terms for each PWC customer. The manager must find better ways in completing customer orders faster. One tool that can assist the manager is having the ability to take a snapshot of today's workflow coming in and out of the PWC system and accurately forecast the amount of work the PWC can accept and still meet the goal.

C. LIMITATIONS TO RESEARCH

One limitation of this research is that only one PWC was used, PWC Pearl Harbor, to develop the model. Each PWC operates differently, so a forecasting model would have to be customized to each PWC. Another limitation was that there were only 45 months of historical data available. There are several methodologies available to select variables for the forecasting model, however this research is only exploratory so a limited number of methodologies were used. It was not possible to test alternative statistical models.

D. PREVIEW OF THESIS ORGANIZATION

Chapter Two briefly gives a background of the NIF and how a typical PWC is organized. In order for the reader to fully understand the problem of fund carryover a knowledge

of the organizational PWC structure is essential. There is also a discussion of how the fund carryover is calculated.

Chapter Three focuses on the methodology used and the type of data gathered. There are several methods that are available to generate a forecast. Each method has its advantages and disadvantages.

Chapter Four presents the development of the forecasting model. A portion of historical data obtained by the author required transformation to give the data uniformity. Several techniques were used to decide upon the best independent variables for the model. The model was tested using FY 88 data.

Chapter Five discusses the usefulness of the model and the carryover goal. The PWC manager does not have many options available to reduce carryover. There are several factors that should be considered when the PWC determines what the carryover target should be. The forecasting model developed by this research is not perfect, but there are ways to improve the model.

II. THE NIF CONCEPT AND ORGANIZATION OF THE PWC

This chapter discusses the typical PWC organization, the development of the NIF, and the fund carryover goal. The PWC is structured like a business that provides a wide variety of customer services (i.e., Sears). There is always a delay between when the business incurs costs for a customer order and billing the customer. However, for a PWC, a significant portion of these delays are longer than one year and this is where fund carryover becomes important.

A. PWC ORGANIZATION

The Public Works Centers (PWCs) are one of several different type of activities under Naval Facilities Engineering Command (NAVFAC) authority.

The need for PWCs became apparent when large naval installations, such as San Diego, California, had several Public Works Departments (PWD). A PWD was a department within an activity and each activity had one. Each PWD

merely provided services for their own activity. The activity commanding officer had a lot of flexibility in work accomplishment. However, there was significant duplication of services. A single PWC in that location to replace several PWDs would provide economies of scale for services and reduce costs in the DOD Budget. The current nine PWCs are:

Public Works Center, Norfolk, VA
Public Works Center, Pearl Harbor, HI
Public Works Center, Guam, M.I.
Public Works Center, Subic Bay, Luzon, R.O.P.
Public Works Center, San Diego, CA
Public Works Center, Pensacola, Fl
Public Works Center, Great Lakes, IL
Public Works Center, San Francisco, CA
Public Works Center, Yokosuka, Japan

All of the PWCs are NIF activities except for PWC Yokosuka which is an Operation and Maintenance Navy (O&MN) Fund activity.

The elementary PWC organization is shown in Figure 1. Customarily, military personnel in PWC senior management positions (commanding officer, executive officer, and production officer) have extensive academic, technical, and professional training. They bring to their PWC

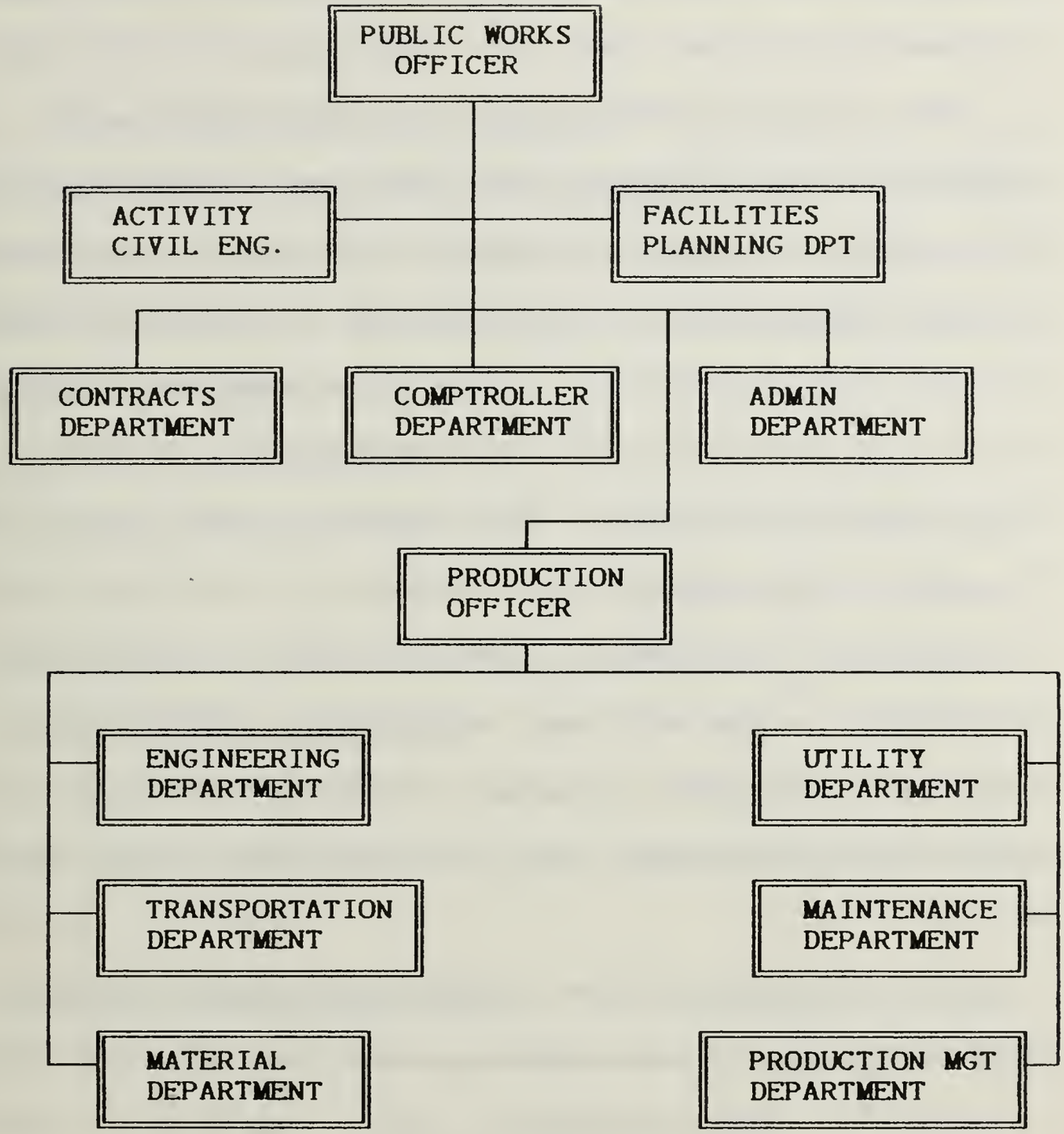

Figure 1. Basic PWC Organization

assignments the wide range of job experiences in other engineering billets. [Ref. 4:p. ORG-5]

The civilian work force, on the other hand, is composed largely of people who have made a career at the PWC. The typical civilian career pattern is to start out at entry-level positions and work up through the system to supervisory positions. They have long histories in the local community and a strong communication network within their work force. This stability is an asset to the PWC, but there is a drawback. It does not necessarily stimulate personal and professional development. The military personnel at PWCs are far ahead of the PWC civilian workers in terms of professional development and job experience. [Ref. 4:p. ORG-6]

The following is a brief description of the responsibilities of each department:

ACTIVITY CIVIL ENGINEERS (ACE): The ACE, a CEC officer or civilian on the PWC staff, serves as the principal liaison between the PWC and other activities

which receive public works support and who do not have a Staff Civil Engineer.

FACILITIES PLANNING DEPARTMENT: This department has responsibility for the administration of the shore facilities planning program, conduct engineering investigations, and administration of the Weight Handling Equipment inspection.

CONTRACTS DEPARTMENT: This Department provides the day-to-day administration and awarding of Facilities Support Contracts. These are maintenance service, indefinite delivery maintenance construction contracts.

COMPTROLLER DEPARTMENT: This department maintains accounting controls on PWC operating budgets and provides financial control of job orders written against such budgets.

ADMINISTRATIVE DEPARTMENT: This department provides administrative, personnel, and managerial support to the center.

PRODUCTION OFFICER: The production officer is a military person from the Civil Engineering Corps community. This person is responsible for overall

management of the production department (utilities, engineering, maintenance, production management, transportation, and material).

UTILITY DEPARTMENT: This department is responsible for a wide range of utilities which include: operation of electrical, generation, transmission, and distribution systems; potable water, sewage treatment, industrial waste water treatment, and hazardous waste collection and disposal; steam and air generation, and distribution systems.

ENGINEERING DEPARTMENT: This department is responsible for engineering consultation, investigation and design directly supporting maintenance, repair and alteration work accomplished with in-house forces or by contract.

MAINTENANCE DEPARTMENT: This department performs preventive maintenance, emergency and service work, and other facility maintenance. This includes, when authorized, repair, alteration, and minor construction.

PRODUCTION MANAGEMENT DEPARTMENT: This department is responsible for scheduling the workflow of the production

department. They decide if a customer request is performed with in-house forces or by contract. They also provide liaison between the PWC and the customer.

TRANSPORTATION DEPARTMENT: This department provides transportation and equipment services to all components of the PWC and customer activities. Additional duties are: (1) operating vehicle and equipment pools; (2) providing crane and rigger service; (3) testing and licensing of operators; and (4) operating scheduled and unscheduled passenger and freight transport systems.

MATERIAL DEPARTMENT: This department supplies the material for the maintenance and repair jobs done by the PWC. The PWC cannot provide the customer material only, because the material must be connected to a specific job. [Ref. 5:pp. 5-54]

Some PWCs may have a Family Housing Department which would be responsible for management of all aspects of family housing.

B. DEVELOPMENT OF THE NIF

Industrial Funds in the Department of Defense (DOD) were authorized by Title IV of the National Security Act Amendments of 1949. During World War II there was an intense mobilization of the nation's industrial base, which resulted in inadequate cost control of military expenditures. The reason for the creation of industrial funds was to improve the economy and efficiency of the industrial and commercial activities of the military departments. The first industrially-funded activity in the Department of the Navy was the Defense Printing Service which was converted to NIF operations on November 1, 1949. [Ref. 6:p. 13]

Today the Navy operates 51 activities under the NIF. An activity can be a Shipyard, PWC, Aircraft Rework Facility, etc. For reporting and budgeting purposes, these commands are organized into 14 separate groups. Organizational control and responsibility for these activities are assigned to Activity Group commanders who are usually major claimants or systems commands. Overall NIF management is provided by the NAVCOMPT. This

management is only financial. Operational management is performed by the Activity Group commanders. The NAVCOMPT guidance often influences the PWC operations. This is in contrast to the business community where the actions of the Comptroller assist the managers in executing the operations of the company.

Eight PWCs form one of the activity groups which come under the control of the NAVFAC [Ref. 7:p. 27]. PWCs, to a much greater extent than other NIF activities, provide services (i.e., utilities, construction, transportation, etc.) to a wide range of customers outside the NAVFAC Command authority. The contractual association between the customer and PWC, the cost accounting system (including numerous claimants and fund sources), and budgetary flexibility provide the framework for a business-like operation.

The original design of the NIF was to become self-sustaining once Congress provided it with an initial cash allocation called a "corpus". The fund would finance the complete cycle of operations by a member activity. The cash available in the corpus would be used initially to

fund the costs of producing goods or services ordered by "customers". Hence, it is often called "working capital". A customer could be any governmental element or selected private sector party. The proceeds from the sale of these goods or services through reimbursement by the customer are deposited back into the industrial fund account to finance subsequent activity. Thus, the creation of the industrial fund helps avoid annual appropriations to finance the daily operation of a NIF activity. [Ref. 6:p. 15]

PWC activities budget for estimated expenses that are expected to occur in a given period of time. Using a three year cycle, the PWCs develop cost budgets reflecting DOD approved escalation factors. The first year of that three-year budget is the next fiscal year's budget. These budgets are then submitted for further review by analysts up the chain of command.

The objective of operations under the Navy Industrial Fund is to have reimbursements for services equal actual cost by type of support or service furnished (i.e., zero profit). Accordingly, in establishing predetermined

rates and applied overhead rates, consideration will be given, not only, to anticipated costs for the budget period, but also to operating gains or losses in prior periods of the current fiscal year. The PWC comptroller establishes rates at a level which will absorb such gains or losses on a planned, systematic basis to attain the objective of zero profit or loss from operations. Rates are established on an annual basis recognizing that seasonal trends will result in offsetting gains or losses. [Ref. 8:p. Appendix H-9]

The NAVCOMPT manual gives a excellent definition on what is the general goal of the NIF for the PWCs.

> The use of Navy Industrial Fund (NIF) funding at PWC activities provides a means of financing inventories with the convenience of using working capital for fully charging costs prior to distribution of these costs to particular customers and funding sources. PWC activities and their customers rely on this revolving fund to finance supplies and materials used, services rendered and labor costs through an involved system of charges to applicable customer appropriation or payments received in cash. [Ref. 8:p. Appendix H-7]

C. FUND CARRYOVER

An in-depth discussion of fund carryover should begin with how it is calculated. The computation of carryover is as follows: [Ref. 3]

1. Balance of customer orders at beginning of year (beginning carryover from previous year),
2. Plus new customer orders received (estimated new customer funding for year),
3. Less revenue (estimated customer billing for year),
4. Less Work in progress (WIP)
5. Less direct material inventory (DMI)
6. Equals gross carryover.

NIF customers are funded with appropriated dollars that usually expire at end of federal fiscal year, September 30. These customers have three methods of placing an order: (1) Work Request (WR); (2) Project Order (PO); and (3) Direct Cite Fund. The funds on a WR and Direct Cite Fund are only available for one fiscal year. WRs can be used for in-house or contract work whereas Direct Cite Funds are only for contract work. In-House work is work that is performed by PWC employed personnel. The funds on a PO are available for three

fiscal years. The important criterion for a PWC PO is that 20% of the work must be done in house.

The use of a WR or a PO results in a obligation upon submission of the order to PWC. Then the PWC uses its NIF funds to produce the order. At completion the PWC bills the customer for the service which is a fund outlay or expenditure for the customer against the obligation. This financing, whereby the PWC pays for the initial cost for an order, is termed washing the money through the NIF account. Since work request funds are valid for one year, for WRs not likely to be completed prior to Sept. 30, the PWC analyzes the remaining obligated amount of each WR. It either returns the balance (initial obligated amount - expenditures) to the customer or asks the customer to convert the WR to a PO [Ref. 9].

The WR is used primarily for recurring work, such as utilities, equipment maintenance, vehicle rental, emergency service, etc. WRs can be used for specific maintenance work which is minor construction or repair, but it must be completed by the end of the fiscal year.

The PO is used for specific work, that is non-routine, long-term, and large dollar cost. Some of the POs are, at end of the fiscal year, converted WR. A large dollar amount of the POs are for specific work that was given to the PWC during the last quarter of the year (year-end dump). The customer submits these orders to the PWC as POs because the PWC has informed them that there is no way the PWC can complete the jobs before Sept. 30. A large portion of the year-end carryover figure can be attributed to this year-end dump [Ref. 10].

One aspect to the year-end dump problem is the lack of better planning by the customer during the first three quarters of the fiscal year. The reasons are twofold : (1) the lack of understanding, by the customer, of the complexity of the PWC system in executing large dollar orders; and (2) fund carryover is not a concern of the customer. The PWCs realize this and are attempting to work closer with the customer by starting earlier in the fiscal year.

The Direct Cite Funding is only used for contract work. The types of contracts are: (1) open-end

contracts; (2) facility service contracts; (3) job order contracts; and (4) construction contracts. These contracts are awarded by the PWC contracts department or the local Officer In Charge of Construction (OICC) office depending upon the dollar value of the contract. When a contract is awarded, the customer sends over a Direct Cite Fund to the OICC or the PWC contracts division. The customer funds are obligated at this point. Expenditure of the customer's funds occurs when the contractor bills the OICC or PWC contracts department for services performed.

An advantage of Direct Cite Funding is that the funds completely bypass the PWC NIF system and it does not affect carryover. A disadvantage, to the customer, is that fund obligation only occurs after contract award. It can take three to four months to complete a contract write up especially if design is necessary. This long lead time from contract write up to contract award precludes the customer from using Direct Cite Funding to obligate his year end dump jobs that are new requirements.

Also, a drawback for the PWC is that it does not get credit for that volume of business done by direct cite funding. A Pacific Naval Facilities Engineering Command study on PWC Pearl Harbor carryover revealed PWC Pearl Harbor could have significantly reduced the carryover balance by planning customer workload earlier in the fiscal year and direct citing the large year-end dump jobs. [Ref. 3]

The issue of fund carryover became a hot topic when, at the end of FY 85, Congress noticed that the total NIF corpus had a large carryover. This was not a one year event, the NIF carryover had been growing from year to year since FY 80. The bulk of the dollar amount of carryover was composed of POs, so money that was budgeted and appropriated to be spent in one year was being used for three years. Congress' concern was that the Navy was trying to extend the life of an appropriation. [Ref. 11]

Congress' interest was translated into guidance issued by OSD and NAVCOMPT. The NIF activity groups were given targets to manage by. The following were the NAVCOMPT targets for FY 87: [Ref. 2]

Activity Group	Net Available ($ in Thousands)
Shipyards	$1,674,164
Ordinance	970,938
NARF	644,994
AEC	392,367
Air Labs	209,864
MSC	59,508
SPAWAR Labs	195,293
NPPS	24,145
NRL	22,400
PWC	118,166
NCEL	12,262
NARDAC	13,509
Total NIF	$4,337,610

An interview with Mr. Curran Smith, NAVFAC Code 162, indicated that there was no particular scientific method used by NAVCOMPT to assign the targets to each NIF activity group. NAVFAC then took the assigned PWC group figure and divided it up between each PWC. NAVFAC analyzed each PWC workload and backlog to develop each PWC target figure. NAVFAC knew it would not be able to reach FY 87 targets, because the targets were a big drop from the previous year. However, the PWC group did make substantial progress in reducing carryover in FY 87 such that the FY 88 target was about the same. [Ref. 10] The following are the PWC carryover targets for FY 87 to 89:

CARRYOVER TARGETS
(DOLLARS IN THOUSANDS)

PWC	FY 87	FY 88	FY 89
GREAT LAKES	$10,338	$6,500	$5,900
GUAM	14,057	13,000	11,384
NORFOLK	33,005	25,000	18,000
PEARL HARBOR	35,711	30,931	25,011
PENSACOLA	8,431	7,400	6,400
SAN DIEGO	25,734	23,800	19,095
SAN FRANCISCO	22,515	19,900	16,800
SUBIC BAY	19,232	18,400	17,400
TOTAL	$169,023	$144,931	$119,990

The targets for FY 90 and FY 91 are the same as FY 89. [Ref. 12]

NAVFAC's view of the carryover problem is that the PWCs are not gaining on their backlog. 95% of the dollar value of backlog is specific maintenance work. This backlog is composed of year-end dump or older work that was year-end dump from prior years. A certain amount of backlog is necessary to sustain operations. NAVFAC's policy is that optimum backlog should be based upon a 90 day backlog of specific maintenance work and a reasonable level of personnel resources. This policy would be realistic if all the backlog were to be accomplished by PWC in-house personnel. Historically, the process to design and award an average contract can take longer than

three months. The composition of the backlog should be used as a factor in determining the backlog policy.

D. SUMMARY

The NIF concept and the organizational structure of the PWC gives the PWC the framework to operate similar to a commercial business entity. PWC customers are required to use PWCs for maintenance services, because they do not have their own PWDs anymore. One advantage of NIF concept over yearly appropriations, is that it allows the PWC to focus completely on workload as the criteria to arrange their workforce.

The NAVFAC philosophy of reducing fund carryover to a goal of one month backlog runs counter to normal business practices. A business establishment would like to keep fund carryover as high as possible. The PWC cannot refuse work but at the same time must keep fund carryover to a low level.

III. METHODOLOGY AND FORECASTING MODELS

This chapter discusses the methodology in conducting the research and types of forecasting models. An initial step in developing a forecast is trying to identify all the relevant variables to the variable to be forecasted. A follow-on to that process is evaluating the historical data.

A. FORECASTING MODELS

The general purpose of this research is to gather historical data and examine its usefulness in predicting a future event. The author obtained monthly historical data from FY 85 to FY 88 on fund carryover from PWC Pearl Harbor. The PWC Pearl Harbor comptroller department did not have historical data prior to FY 85 readily available. Those files had been placed into storage.

Only one PWC was used to develop the forecasting model. Even though each PWC has the same basic organizational structure they each operate uniquely. So

a forecasting model for one PWC will not work for the others. The model has to be customized for each PWC. The selection of PWC Pearl for the initial model was based upon their workload. PWC Pearl does an above average workload compared to the other PWCs. To display the relative size of each PWC, the following is NAVCOMPT's FY 89 budget submission for the PWCs:

BUDGET SUBMISSION TO NAVCOMPT
(DOLLARS IN MILLIONS)

PWC	FY 89
GREAT LAKES	$65
GUAM	97
NORFOLK	214
PEARL HARBOR	156
PENSACOLA	59
SAN DIEGO	272
SAN FRANCISCO	149
SUBIC BAY	78
YOKOSUKA	77

There are many forecasting methods that can be used to predict future events. These methods can be divided into two basic types: qualitative methods and quantitative methods. Qualitative forecasting methods generally use the opinions of experts to subjectively

predict future events. Such methods are often required when historical data concerning the events to be predicted are not available or are scarce. [Ref. 13:p. 16] Since there is quite a amount of historical data available, only quantitative methods will be used in this research.

1. Time Series

One commonly used technique of quantitative forecasting is the time-series model. Two factors are important in a time-series model: the series we want to forecast (such as yearly population growth) and the period of time we are referring to. The basic underlying assumption of a time-series model is that some pattern is recurring over time. Thus, by identifying the pattern and the starting point for that forecast its value in any subsequent time period can simply be estimated by knowing the number of periods in each cycle of the pattern and the number of periods since the starting point. For example, if we have a forecasting model that has identified a seasonal pattern in which population growth has been 15% below the yearly average every five years,

we know that in any forecast of population for the next five years the growth in the fifth year must be 15% below the average level. [Ref. 14:p. 22]

In addition to the importance of the sequence of the periods as a variable in a time-series model, this model also assumes explicitly that the underlying pattern can be identified solely on the basis of historical data from that series. The disadvantage for the manager is that he/she can not use this model to predict the impact of certain decisions he/she may make. Any forecasting method that uses a time-series model will give the same forecast for the next period, no matter what the manager's actions may be. Thus a time-series model may be appropriate for forecasting factors over which the manager has no control such as rate of inflation and level of employment, but may be inappropriate for forecasting weekly sales resulting from changes in pricing and advertising. [Ref. 14:p. 22]

The accounting rules for PWCs are oriented toward sequential time periods (days, months, years), so that data gathered on the basis of these time periods can be

used in the application of a time-series forecasting technique. This is one benefit of time-series models. [Ref. 14:p. 22]

a. Components of Time Series

To operate with the assumption that time series data are composed of a historical pattern that can be exploited in the preparation of a forecast, it is helpful to think of a time series consisting of the following components: (1) trend; (2) cycle; (3) seasonal variations; and (4) irregular fluctuations.

Trend refers to the upward or downward movement that characterizes a time series over a long period of time. Thus, trend reflects the long-run growth or decline in the time series.

Cycle alludes to recurring up and down movements around trend levels. These fluctuations can have a duration of anywhere from 2 to 10 years or even longer measured from peak to peak or trough to trough.

Seasonal variations are periodic patterns in a time series that complete themselves within the period

of a calendar year and are then repeated on a yearly basis.

Irregular fluctuations are erratic movements in a time series that follow no recognizable or regular pattern. Such movements represent what is "left over" in a time series after trend, cycle, and seasonal variations have been accounted for. Many irregular fluctuations in time series are caused by "unusual" events that cannot be forecasted (e.g., earthquakes, accidents, hurricanes, wars, wildcat strikes, and the like). Irregular fluctuations can also be caused by errors of the time series analysts. [Ref. 13:pp. 6-9]

2. Causal Model

Another type of quantitative forecasting is the causal model, the techniques of which assume that the value of a certain variable is a function of several other variables. In a very narrow sense a time-series model could be called a causal model, since the actual values are assumed to be a function of the time period alone. The term "causal model", however, is generally reserved for models with variables other than time. Once

these related variables have been identified, a statistical model that describes the relationship between these variables and the variable to be forecast is developed. The statistical relationship derived is then used to forecast the variable of interest. An example would be an equation for predicting sales that bases its forecast on the values of price and advertising within the company and the industry; that is, the equation would state that sales are a function of the other variables. [Ref. 14:p. 22]

The business community finds causal models valuable because they allow management to evaluate the impact of various optional policies. For example, management might wish to predict how various price structures and levels of advertising expenditures will affect sales. A causal model relating these variables could be used here. However, causal models have several obstacles. A considerable amount of historical data is necessary not only for the variable to be forecast, but for all the variables that are to be included in the model. Another obstacle is that they are quite difficult

to develop. Besides this, the ability to predict the dependent variable depends on the ability of the forecaster to accurately predict future values of the independent variables. Despite these disadvantages, causal models are often used to generate predictions. [Ref. 13:p. 21]

B. METHODOLOGY

The author of this thesis conducted the research in two phases: (1) data collection; and (2) development of the forecasting model.

The data collection phase involved the author visiting a Public Works Center, PWC Pearl Harbor. The concept for the thesis research was developed by this activity. Discussions were held with the Executive Officer, Comptroller department, and Production Management department.

The PWC Pearl Comptroller department is responsible for tracking carryover. They can calculate fund carryover on a monthly basis, but there is no formal method to forecast carryover. Figure 2 shows the March

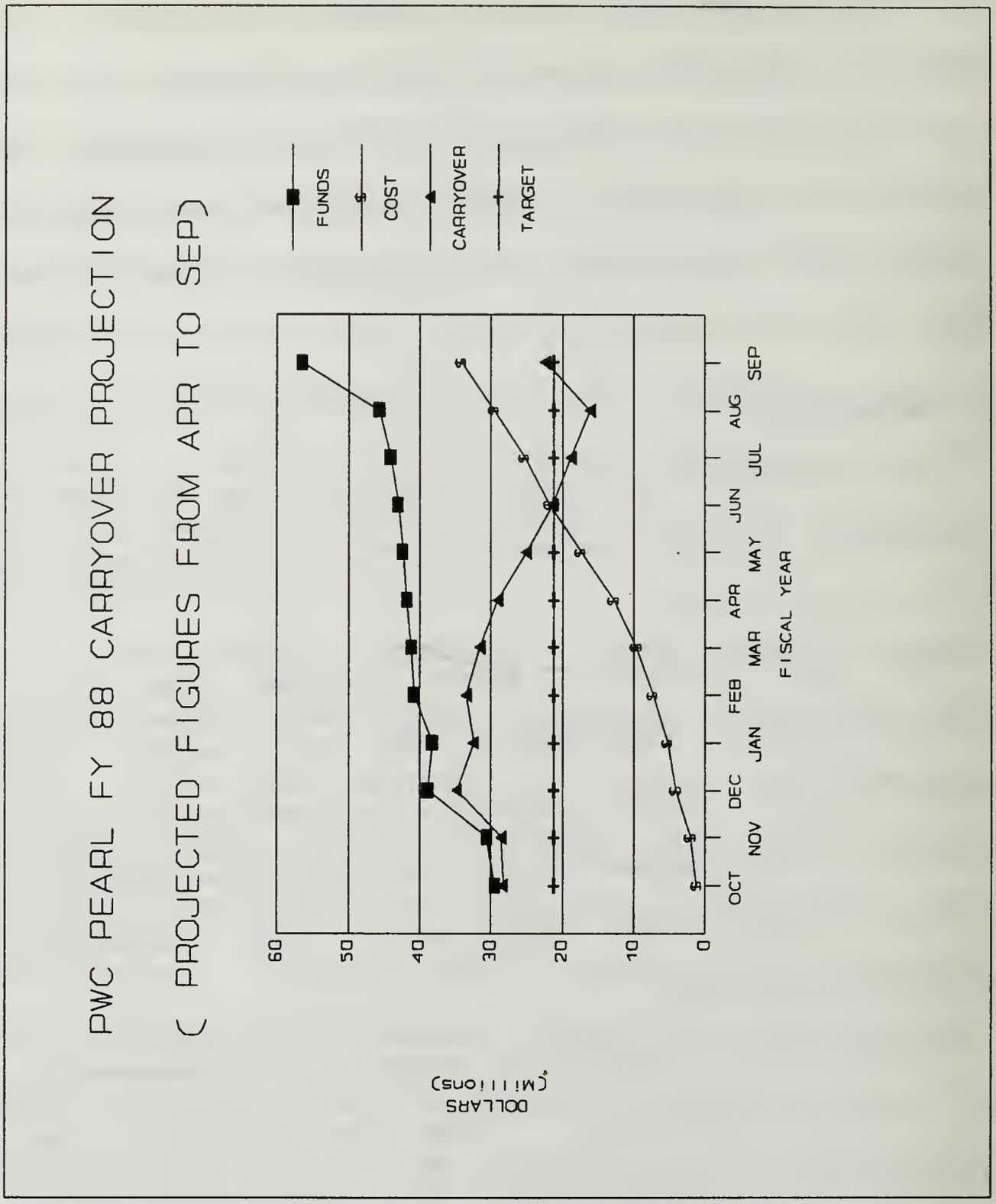

Figure 2. March Carryover Chart

1988 carryover chart. Cost is the sum of the monthly billings to customers and work in place that has not been billed for specific work. Funds are the monthly cumulation of customer funds for specific jobs received by the PWC. The target figure is the carryover goal ($21 Million). Carryover is the difference between the Funds Received and Cost figure plus the previous month carryover. Actual figures for Cost, Funds, Carryover were used for October to March. The figures for April to September are projections. No mathematical method was used to develop these projections. So as a precise tool for the manager these projections are not very helpful.

The items that are a part of the carryover computation are: (1) Funds Received; (2) Billings; and (3) Work in Place. Monthly historical data were obtained from FY 1985 to FY 1988 for these items plus the carryover amount.

C. CHARACTERISTICS OF DATA

The Comptroller Department changed the monthly carryover calculation at the end of Fiscal Year 1987.

Prior to FY 1988 the Comptroller Department included recurring funds received and billed in their carryover calculation. Only a very small portion of recurring workload carries over at the end of the year, because of the nature of the work (i.e., utilities, equipment maintenance, equipment rental, etc.). So the amount ordered by customers, will for all practical purposes, equal the amount billed.

FY 88 data for funds received, billing, and work in place was for only specific work. FY 85 to FY 87 data contained specific and recurring workload. There was no way to break out actual recurring workload from that data without going through a laborious manual search of old reports. The PWC Pearl Administrative department, which produces accounting reports for the center, does not keep information on computer tape longer than one fiscal year.

Two alternatives were available to correct the data. To make FY 88 data similar in composition to FY 85-87 data either recurring workload has to be subtracted from FY 85-87 data or added to FY 88 data. Recurring workload for FY 88 was readily available. Recurring workload for

FY 85-87 could be estimated from FY 88 data, because recurring workload is basically the same from year to year except for some minor fluctuations. However, the error in these estimates would be added to the FY 85-87 data. Since adding recurring workload to FY 88 data would reduce the amount of error, this alternative was selected.

There was no FY 85 monthly data available for WIP (Work In Progress). This variable can be calculated if these figures are available: (1) Carryover at the end of FY 84; (2) Funds received; (3) Billings; and (4) Monthly carryover. The figure that was not available was Carryover at the end of FY 84. This figure can be estimated and the computed WIP can be compared to the WIP for FY 86-88. If the FY 85 WIP seems way out of range, then the estimated, end of FY 84, Carryover will be changed.

1. Other Variables

There are other variables that might have a statistical relationship to carryover. A large portion of the carryover is composed of backlog. This backlog is

for specific work which is split between contract work and in-house. The PWC Pearl Contract Department did not have any historical data on contract workload prior to FY 87. There would not be enough data to use in a model.

The PWC Pearl Production Management Department controls the workload coming into the center. They make the decision on whether a customer order is done by contract or by in-house forces. An interview with Mr. Clay Au, the department head, expressed that his department tightly manages the specific work backlog for the in-house forces. Contract work is used as residuals after in-house forces are taken care of. There is a weekly specific backlog report that is used by the department. This report gives number of personnel and shop days of backlog. Multiplying the number of personnel by shop days provides man-days of backlog. Then the man-days of backlog is multiplied by $410/day to determine the amount of backlog in dollar terms. The figure of $410/day was the number the Department said was the average cost per day per man to do specific work.

This figure also includes material cost. Monthly historical data from Fiscal Year 1985 were obtained.

D. SUMMARY

The quantitative method of forecasting a future event was chosen due to the fact that sufficient historical data were available. Either the time series or the causal model, types of quantitative methods, can be used as a forecasting technique. However, the time series model can not be used to predict the impact of certain decisions the manager makes.

The author collected monthly historical data from FY 85 to FY 88 for these items: (1) Funds Received; (2) Billings; (3) Work in Place; and (4) Fund Carryover. The two problems with the data were: FY 85 WIP was not available; FY 85-87 data included specific and recurring work whereas FY 88 data only had specific work. These two problems were solved.

IV. ANALYSIS OF THE DATA AND THE MODEL DEVELOPMENT

This chapter discusses the transformation of the original data and the development of the forecasting model.

A. DATA TRANSFORMATION

Monthly historical data from October FY 85 to June FY 88 were obtained for the following variables: (1) funds received; (2) billings; (3) backlog; (4) WIP; and (5) carryover. FY 85 data for WIP were not available. Figure 3 lists the original data.

1. Funds Received

As discussed in Chapter III, the variables "funds received" and "WIP" were not in the proper format. FY 85-87 funds received data included funds for recurring and specific work, whereas the FY 88 data only contained specific work. The method chosen to make all funds received data similar was to add the funds for recurring work to FY 88 data. Recurring workload for FY 88 was

		FUNDS REC	BILLINGS	BACKLOG	WIP	CARRYOVER
FY 85	OCT	$33,770,729	$8,354,781	$12,460,720	$0	$51,029,651
	NOV	$14,375,186	$18,352,392	$13,401,465	$0	$50,444,661
	DEC	$11,550,047	$11,969,898	$12,900,486	$0	$50,432,844
	JAN	$14,877,437	$12,205,854	$12,295,982	$0	$50,221,698
	FEB	$12,553,024	$12,815,248	$11,731,740	$0	$50,114,870
	MAR	$13,351,508	$15,956,251	$11,145,317	$0	$48,680,351
	APR	$9,485,230	$14,258,894	$10,901,408	$0	$44,650,450
	MAY	$16,015,465	$14,929,588	$11,090,664	$0	$46,694,860
	JUN	$6,706,376	$12,059,020	$10,796,940	$0	$43,126,874
	JUL	$21,291,662	$15,978,615	$10,269,762	$0	$47,525,627
	AUG	$2,876,868	$9,887,374	$10,649,709	$0	$37,044,147
	SEP	$24,629,144	$16,320,259	$10,478,124	$0	$45,196,514
FY 86	OCT	$16,524,828	$11,556,605	$9,757,344	$7,673,753	$46,289,362
	NOV	$14,712,514	$10,409,679	$10,291,820	$8,304,635	$49,961,315
	DEC	$13,019,902	$12,137,070	$11,033,100	$7,668,536	$51,480,247
	JAN	$27,289,683	$15,047,257	$11,610,216	$6,841,215	$64,549,993
	FEB	$7,914,978	$15,204,479	$12,158,468	$7,115,366	$56,986,341
	MAR	$7,291,029	$13,270,636	$12,328,700	$6,296,455	$51,825,645
	APR	$21,278,167	$15,053,812	$11,981,184	$5,691,840	$58,654,615
	MAY	$4,940,880	$13,590,923	$11,370,981	$5,523,128	$50,173,284
	JUN	$10,361,611	$12,967,971	$10,378,986	$5,581,076	$47,508,976
	JUL	$17,010,778	$12,644,891	$9,457,716	$7,053,946	$50,401,993
	AUG	$2,770,534	$12,624,175	$9,665,832	$7,291,255	$40,311,073
	SEP	$7,670,747	$20,562,347	$10,606,864	$3,749,769	$30,960,930
FY 87	OCT	$30,324,546	$8,274,815	$9,954,308	$8,362,333	$48,398,097
	NOV	$6,909,029	$11,521,608	$12,036,083	$9,474,519	$42,673,332
	DEC	$17,282,955	$15,500,860	$10,919,776	$6,905,516	$47,024,430
	JAN	$17,714,501	$13,207,190	$11,090,664	$7,047,080	$51,390,177
	FEB	$11,661,650	$13,217,404	$10,174,642	$6,314,807	$50,566,695
	MAR	$11,405,966	$14,009,901	$8,265,969	$7,274,367	$47,003,200
	APR	$22,226,661	$13,560,142	$7,612,880	$7,024,398	$55,919,689
	MAY	$1,404,707	$11,578,478	$6,393,048	$8,305,110	$44,151,041
	JUN	$10,810,677	$11,714,492	$6,656,760	$10,009,150	$41,540,096
	JUL	$15,326,251	$16,353,882	$6,280,380	$7,812,051	$43,026,818
	AUG	$7,127,058	$12,862,265	$5,633,277	$7,830,183	$37,266,417
	SEP	$16,912,541	$21,361,156	$5,379,528	$4,944,488	$35,710,559
FY 88	OCT	$29,540,000	$8,333,333	$5,910,437	$1,183,000	$28,357,000
	NOV	$1,062,000	$9,289,333	$7,626,000	$1,077,000	$28,569,000
	DEC	$8,331,000	$8,988,333	$7,976,960	$1,536,000	$34,830,000
	JAN	($713,000)	$8,165,333	$7,228,095	$1,249,000	$32,461,000
	FEB	$2,558,000	$8,230,333	$6,911,247	$1,984,000	$33,444,000
	MAR	$1,425,000	$8,633,333	$6,825,434	$2,600,000	$29,025,000
	APR	$1,653,000	$10,134,333	$6,732,528	$1,216,000	$32,209,000
	MAY	$2,124,000	$9,385,333	$6,642,000	$402,000	$30,654,000
	JUN	$1,830,000	$6,466,333	$6,538,680	$1,520,000	$28,740,000

Figure 3. Original Historical Data

approximately $100 million. Funds received for recurring work is spread evenly throughout the year. Dividing $100 million by 12 months results in a $833,333 monthly average recurring funds received. So this average was added to each month. The following is the FY 88 funds received data with and without the recurring workload.

FY 88	ORIGINAL FUNDS RECEIVED	REVISED FUNDS RECEIVED
OCT	$29,540,000	$37,873,333
NOV	1,062,000	9,395,333
DEC	8,331,000	16,664,333
JAN	(713,000)	7,620,333
FEB	2,558,000	10,891,333
MAR	1,425,000	9,758,333
APR	2,678,000	9,986,333
MAY	2,124,000	10,457,333
JUN	1,830,000	10,163,333

2. FY 88 Billings and WIP

The FY 88 monthly billings and WIP data also required the addition of the effect of recurring workload. The PWC Pearl Harbor Comptroller department was able to provide the actual recurring workload

figures. Below are the original and revised data for monthly billings and WIP.

ORIGINAL

FY 88	WIP	BILLINGS
OCT	$1,183,000	$0
NOV	1,077,000	956,000
DEC	1,536,000	2,567,000
JAN	1,249,000	4,010,000
FEB	1,984,000	5,350,000
MAR	1,964,000	7,000,000
APR	1,216,000	10,431,000
MAY	402,000	14,924,000
JUN	1,520,000	17,550,000

REVISED

FY 88	WIP	BILLINGS
OCT	$11,552,000	$10,000,000
NOV	15,263,000	10,956,000
DEC	10,405,000	11,611,000
JAN	9,497,000	11,443,000
FEB	10,374,000	11,340,000
MAR	12,723,000	9,341,000
APR	14,313,000	10,431,000
MAY	18,874,000	14,924,000
JUN	10,962,000	17,550,000

3. FY 85 WIP

The actual figures for FY 85 WIP were not available because the PWC had put their records into storage. The WIP can be recalculated accurately using this formula:

Carryover at the end of FY 84

+ Orders received (year to date)

- Billings (year to date)

- Monthly carryover

= WIP

The figure that was not available was Carryover at the end of FY 84. The author used the FY 85 October funds received ($33,770,729) as an estimation for the Carryover at the end of FY 84. The actual number would probably be several million dollars below this figure.

The resulting calculations are shown below:

FY 85 WIP	
OCT	$8,157,026
NOV	4,764,810
DEC	4,356,776
JAN	7,239,505
FEB	7,084,109
MAR	5,913,885
APR	5,170,122
MAY	4,211,589
JUN	(3,573,069)
JUL	3,341,225
AUG	6,812,199
SEP	6,968,717

Note that the June WIP figure is negative. Discussions with the PWC Pearl Harbor comptroller

department indicated that there are no occasions where the WIP would be negative. The actual figure should be in the three to five million dollar range. To get a number in that range four options are available: (1) increase estimated FY 84 carryover by $8 Million; (2) increase June orders received by $8 Million; (3) decrease June billings by $6 Million; and (4) decrease June carryover by $6 Million.

After comparing the data from the other fiscal years, option four seemed to be the best. Option two or three would provide numbers for orders received or billings way out of normal. The actual carryover for FY 84 had to be below $34 million so option one was not plausible. So FY 85 June carryover was changed from $49,126,874 to $43,126,874. Figure 4 presents the Carryover for FY 85 to FY 88. In each year the June carryover drops as compared to the previous month.

With the change in the June carryover, the calculated June WIP is $2,426,931. Figure 5 lists the WIP from FY 85 to FY 88.

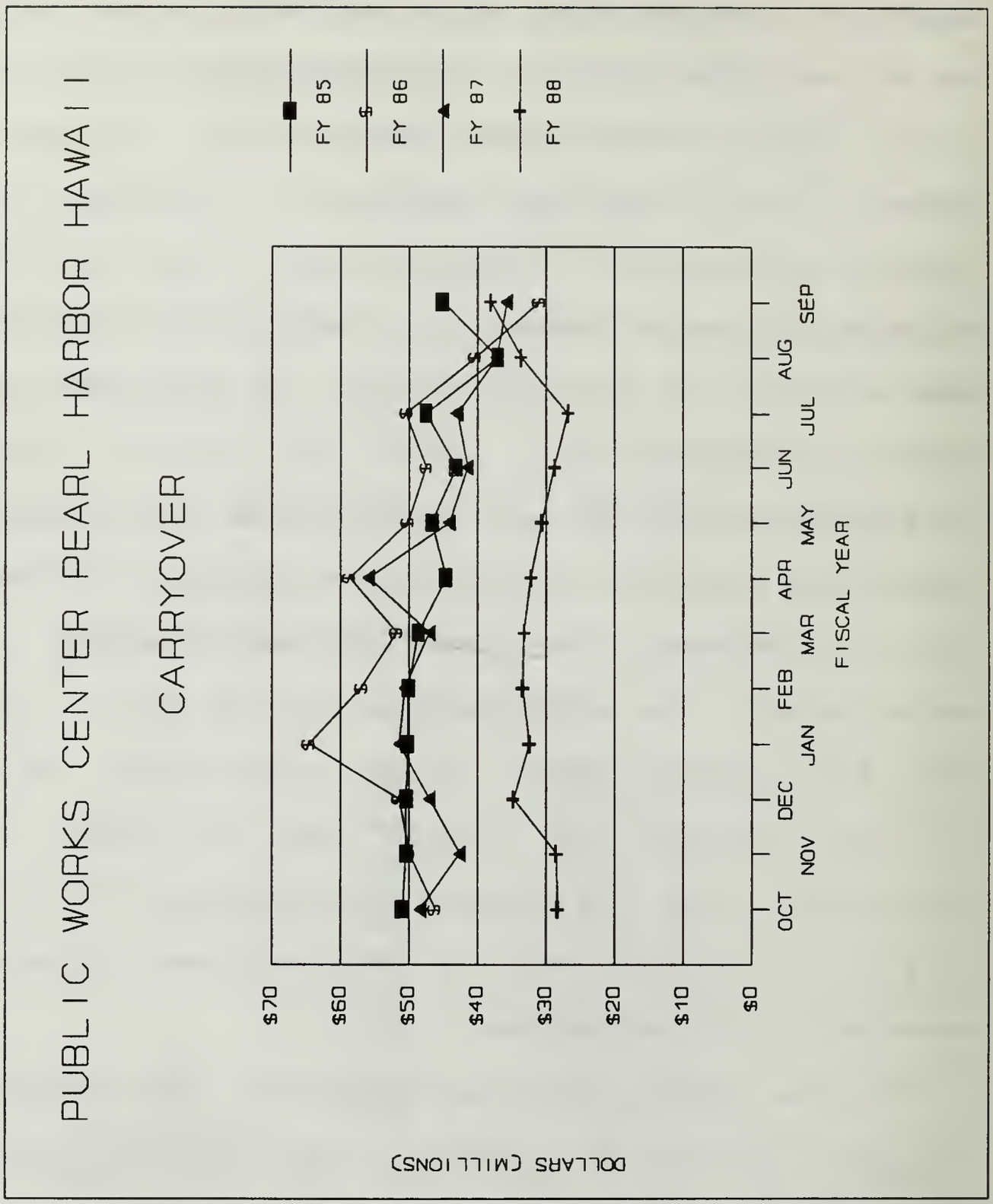

Figure 4. Carryover from FY 85 to FY 88

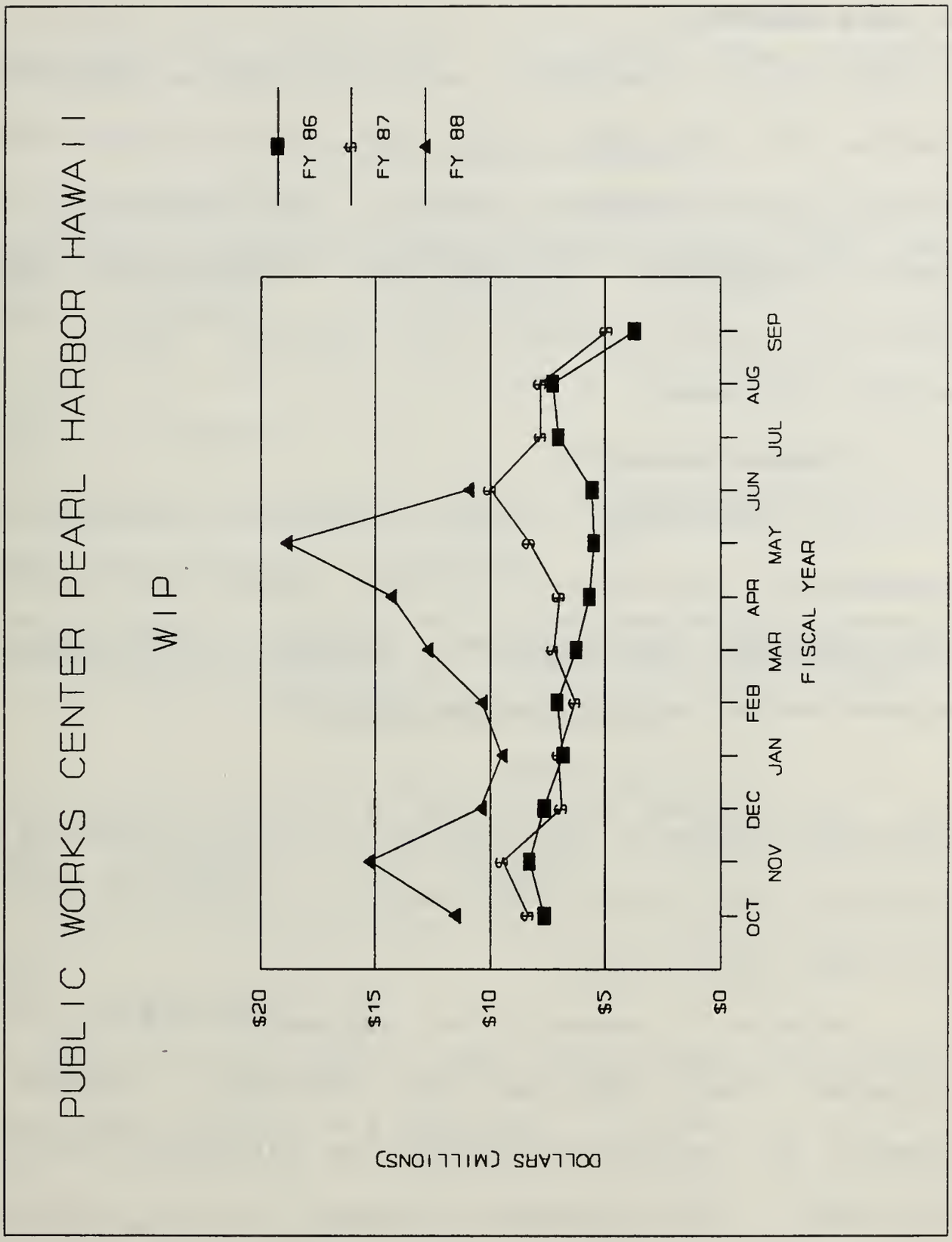

Figure 5. WIP from FY 86 to FY 88

B. DATA ANALYSIS

Each year of monthly data for each variable was combined with the other years. The result is that each variable has 45 elements (months). The objective is to find a relationship to the dependent variable--carryover. Separately each variable was regressed against the variable carryover.

1. Simple Regression

In conducting a simple regression analysis the assumption is that there is a linear relationship between the independent and dependent variable. This can be represented by the mathematical function:

$$Y = a + bX$$

This equation states that the value of Y is a function of the value of X, where the constants "a" and "b" locate the linear relationship.

Figure 6 presents the regression analysis for variables "funds received" and "billings". Figure 7 presents the regression analysis for variables "backlog" and "WIP". The R-squared figures for the variables "backlog" and "WIP" were 48.00 and 32.28 respectively.

```
Dependent : COMB.CARRYOVER   Independent: COMB.FUNDS_REC

-----------------------------------------------------
                    Analysis of Variance

-----------------------------------------------------
Source Sum of Squares Df Mean Square  F-Ratio Prob. Lev.
Model  2.1814E14       1  2.1814E14    2.935E00  .09390
Error  3.1962E15      43  7.4329E13

-----------------------------------------------------
Total
Corr.  3.4143E0015    44

Correlation Coefficient=0.252763  R-squared=6.39 percent

Stnd. Error of Est. = 8.62144E6

*****************************************************
Dependent:COMB.CARRYOVER     Independent: COMB.BILLINGS
-----------------------------------------------------
                    Analysis of Variance

-----------------------------------------------------
Source Sum of Squares Df Mean Square  F-Ratio Prob. Lev.
Model  9.5294E12       1   9.5294E12   1.203E-1  .73035
Error  3.4048E15      43   7.9181E13

-----------------------------------------------------
Total
Corr.  3.4143E0015    44

Correlation Coefficient=0.0528  R-squared = .28 percent

Stnd. Error of Est. = 8.89834E6
```

Figure 6. Variables Funds Received and Billings

```
Dependent: COMB.CARRYOVER    Independent: COMB.BACKLOG
-------------------------------------------------------

                  Analysis of Variance

-------------------------------------------------------
Source Sum of Squares Df Mean Square F-Ratio  Prob. Lev.
Model   1.6390E15      1  1.6390E15  3.970E1   .00
Error   1.7753E15     43  4.1286E13

-------------------------------------------------------

Total
Corr.   3.4143E15     44

Correlation Coefficient=0.69285  R-squared=48.00 percent

Stnd. Error of Est. = 6.42541E6

*******************************************************
Dependent: COMB.CARRYOVER     Independent: COMB.WIP
-------------------------------------------------------

                  Analysis of Variance

-------------------------------------------------------
Source Sum of Squares Df Mean Square F-Ratio  Prob. Lev.
Model   1.1021E15      1  1.1021E15  2.050E1   .00005
Error   2.3122E15     43  5.3771E13

-------------------------------------------------------
Total
Corr.   3.4143E15     44

Correlation Coefficient=-0.5682  R-squared=32.28 percent

Stnd. Error of Est. = 7.33288E6
```

Figure 7. Variables Backlog and WIP

One way to evaluate the significance of a simple regression equation is to look at whether the two variables are correlated. The R-squared value is also named the coefficient of determination. This figure is a relative measure whether the variables are correlated. This coefficient can vary from 0 (which indicates no correlation) to +/- 1 (which indicates perfect correlation). A positive correlation means the coefficient is greater than 0. A negative correlation means the coefficient is less than 0. The higher the R-Squared value the better. The mathematical relationship is [Ref. 28:p. 85]:

$$r^2 = \frac{\text{explained variation}}{\text{total variation}}$$

Figures 6 and 7 also provide other items. The correlation coefficient is the square root of the R-squared value. Total (Corr.) is the summation of the sum of squares for the Model and the Error terms.

The standard error of estimation is used to develop a confidence interval for any forecast. All the regression analysis performed in this research used a

confidence interval of 95%. This means that, with in 95% confidence, the actual values of carryover will lie within +/- 2 times the (standard errors of estimation) around the forecast value. [Ref. 14:p. 116]

It is necessary to determine the significance of the R-squared value. The common method used is to compare the explained variance and the unexplained variance. The ratio of these two variances is called the F-statistic and can be mathematically expressed by [Ref. 15:p. 13]:

$$F = \frac{R^2 / (k - 1)}{(1 - R^2) / (n - k)}$$

Where: n = the sample size (number of observations)

k = the number of variables.

The value of the F-statistic must be compared with the appropriate entry in a table of values of the F-test to determine whether it is significant at the 95% level. Probability levels in Figures 6 and 7 provide the level of significance. So for funds received (see Figure 6), the probability level is .09390 which is higher than .05 for a 95% level of significance. The interpretation is

that the R-squared value of 6.39% is not significant. [Ref. 14:pp. 87-88]

2. Lagged Simple Regression

Another factor to consider when data are organized in a time sequence, is that there might be a lagged relationship between the dependent and independent variables. This relationship occurs because the impact of the independent variable on the dependent variable may be gradual or delayed. Simple regression analysis was done with lagging the independent variables for one, two, and three months. Figures 8 to 10 show the regression output for lags of one, two, and three months, respectively.

A summary of the R-squared values for all of the simple regressions is shown in Table 1. The highest R-squared values will be used as the selection method in choosing the variables for the model. The best variables for funds received and billings were the ones with no lag. The best variables for billings and backlog were the variables with one and two month lag, respectively.

```
Dependent: LAG1.CARRYOVER   Independent:  LAG1.FUNDS_REC
-----------------------------------------------------
Total (Corr.)          3.3673E0015     43

Correlation Coefficient= 0.021483  R-squared=.05 percent

Stnd. Error of Est. = 8.95197E6

*****************************************************
Dependent: LAG1.CARRYOVER     Independent: LAG1.BILLINGS
-----------------------------------------------------

Total (Corr.)          3.3673E0015     43

Correlation Coefficient= 0.0765  R-squared= .58 percent

Stnd. Error of Est. = 8.92782E6

*****************************************************
Dependent: LAG1.CARRYOVER      Independent: LAG1.BACKLOG
-----------------------------------------------------
Total (Corr.)          3.3673E0015     43

Correlation Coefficient=0.7551  R-squared= 57.02 percent

Stnd. Error of Est. = 5.87004E6

*****************************************************
Dependent: LAG1.CARRYOVER       Independent: LAG1.WIP
-----------------------------------------------------
Total (Corr.)          3.3673E0015     43

Correlation Coefficient=-0.5147  R-squared=26.49 percent

Stnd. Error of Est. = 7.67678E6
```

Figure 8. Variables with One Month Lag

```
Dependent: LAG2.CARRYOVER  Independent: LAG2.FUNDS_REC
-----------------------------------------------------
Total (Corr.)          3.3262E0015     42

Correlation Coefficient=0.07194  R-squared =.52 percent

Stnd. Error of Est. = 8.98365E6

*****************************************************
Dependent: LAG2.CARRYOVER   Independent: LAG2.BILLINGS
-----------------------------------------------------
Total (Corr.)          3.3262E0015     42

Correlation Coefficient=0.0452  R-squared =.20 percent

Stnd. Error of Est. = 8.99778E6

*****************************************************
Dependent: LAG2.CARRYOVER      Independent: LAG2.BACKLOG

-----------------------------------------------------
Total (Corr.)          3.3262E0015     42

Correlation Coefficient=0.7579  R-squared= 57.44 percent

Stnd. Error of Est. = 5.87619E6

*****************************************************
Dependent : LAG2.CARRYOVER       Independent : LAG2.WIP
-----------------------------------------------------
Total (Corr.)          3.3262E0015     42

Correlation Coefficient=-0.396  R-squared= 15.68 percent

Stnd. Error of Est. = 8.27065E6
```

Figure 9. Variables with Two Month Lag

```
Dependent: LAG3.CARRYOVER  Independent: LAG3.FUNDS_REC
----------------------------------------------------------
Total (Corr.)          3.2832E0015     41
Correlation Coefficient=0.219146 R-squared= 4.80 percent

Stnd. Error of Est. = 8.83953E6


**********************************************************
Dependent: LAG3.CARRYOVER   Independent : LAG3.BILLINGS
----------------------------------------------------------
Total (Corr.)          3.2832E0015     41

Correlation Coefficient=0.0301661  R-squared=.09 percent

Stnd. Error of Est. = 9.05563E6

**********************************************************
Dependent: LAG3.CARRYOVER       Independent: LAG3.BACKLOG
----------------------------------------------------------

Total (Corr.)          3.2832E0015     41

Correlation Coefficient=0.711847 R-squared=50.67 percent

Stnd. Error of Est. = 6.36298E6

**********************************************************
Dependent: LAG3.CARRYOVER       Independent: LAG3.WIP
----------------------------------------------------------

Total (Corr.)          3.2832E0015     41

Correlation Coefficient=-0.3657  R-squared=13.37 percent

Stnd. Error of Est. = 8.43235E6
```

Figure 10. Variables with Three Month Lag

TABLE I

R-SQUARED VALUES

	FUNDS RECEIVED	BILLINGS	BACKLOG	WIP
NO LAG	6.39%	0.28%	48.00%	32.28%
1 MONTH	0.05%	0.58%	57.02%	26.49%
2 MONTH	0.52%	0.20%	57.44%	15.68%

C. MODEL DEVELOPMENT

The next step is to calculate a multiple regression of all the independent variables against the dependent variable "carryover". The independent variables used are the ones discussed in the above paragraph. The objective is to find the best selection of the independent variables that will produce the best R-squared value. Figure 11 contains the revised historical data.

One method of selecting independent variables is stepwise regression. This method basically employs a series of F-tests to check the significance of independent variables added to the regression function. Also, the significance of the variables already in the

FUNDS REC	ONE MONTH LAG BILLINGS	TWO MONTH LAG BACKLOG	WIP	CARRYOVER
$11,550,047	$18,352,392	$12,460,720	$4,356,776	$50,432,844
$14,877,437	$11,969,898	$13,401,465	$7,239,505	$50,221,698
$12,553,024	$12,205,854	$12,900,486	$7,084,109	$50,114,870
$13,351,508	$12,815,248	$12,295,982	$5,913,885	$48,680,351
$9,485,230	$15,956,251	$11,731,740	$5,170,122	$44,650,450
$16,015,465	$14,258,894	$11,145,317	$4,211,589	$46,694,860
$6,706,376	$14,929,588	$10,901,408	$2,426,931	$43,126,874
$21,291,662	$12,059,020	$11,090,664	$3,341,225	$47,525,627
$2,876,868	$15,978,615	$10,796,940	$6,812,199	$37,044,147
$24,629,144	$9,887,374	$10,269,762	$6,968,717	$45,196,514
$16,524,828	$16,320,259	$10,649,709	$7,673,753	$46,289,362
$14,712,514	$11,556,605	$10,478,124	$8,304,635	$49,961,315
$13,019,902	$10,409,679	$9,757,344	$7,668,536	$51,480,247
$27,289,683	$12,137,070	$10,291,820	$6,841,215	$64,549,993
$7,914,978	$15,047,257	$11,033,100	$7,115,366	$56,986,341
$7,291,029	$15,204,479	$11,610,216	$6,296,455	$51,825,645
$21,278,167	$13,270,636	$12,158,468	$5,691,840	$58,654,615
$4,940,880	$15,053,812	$12,328,700	$5,523,128	$50,173,284
$10,361,611	$13,590,923	$11,981,184	$5,581,076	$47,508,976
$17,010,778	$12,967,971	$11,370,981	$7,053,946	$50,401,993
$2,770,534	$12,644,891	$10,378,986	$7,291,255	$40,311,073
$7,670,747	$12,624,175	$9,457,716	$3,749,769	$30,960,930
$30,324,546	$20,562,347	$9,665,832	$8,362,333	$48,398,097
$6,909,029	$8,274,815	$10,606,864	$9,474,519	$42,673,332
$17,282,955	$11,521,608	$9,954,308	$6,905,516	$47,024,430
$17,714,501	$15,500,860	$12,036,083	$7,047,080	$51,390,177
$11,661,650	$13,207,190	$10,919,776	$6,314,807	$50,566,695
$11,405,966	$13,217,404	$11,090,664	$7,274,367	$47,003,200
$22,226,661	$14,009,901	$10,174,642	$7,024,398	$55,919,689
$1,404,707	$13,560,142	$8,265,969	$8,305,110	$44,151,041
$10,810,677	$11,578,478	$7,612,880	$10,009,150	$41,540,096
$15,326,251	$11,714,492	$6,393,048	$7,812,051	$43,026,818
$7,127,058	$16,353,882	$6,656,760	$7,830,183	$37,266,417
$16,912,541	$12,862,265	$6,280,380	$4,944,488	$35,710,559
$37,873,333	$21,361,156	$5,633,277	$11,552,000	$28,357,000
$9,395,333	$10,000,000	$5,379,528	$15,263,000	$28,569,000
$16,664,333	$10,956,000	$5,910,437	$10,405,000	$34,830,000
$7,620,333	$11,611,000	$7,626,000	$9,497,000	$32,461,000
$10,891,333	$11,443,000	$7,976,960	$10,374,000	$33,444,000
$9,758,333	$11,340,000	$7,228,095	$12,723,000	$33,239,000
$9,986,333	$9,341,000	$6,911,247	$14,313,000	$32,209,000
$10,457,333	$10,431,000	$6,825,434	$18,874,000	$30,654,000
$10,163,333	$14,924,000	$6,732,528	$10,962,000	$28,740,000

Figure 11. Revised Historical Data

model is rechecked once a new variable has been added. If they are not significant they are deleted from the regression function.

Figure 12 illustrates the output of the stepwise regression analysis. The model fitting results provide the variables and constants for the regression equation. The t-value is the coefficient divided by its standard error. The significance level indicates whether the coefficient is significantly different than zero at the 95% confidence level (a value less than .05). The best independent variables are "funds received-no lag" (X_1) and "backlog-two month lag" (X_2) with a R-squared of 64.67%. The resultant regression equation is:

$$Y = \$9,983,215 + 0.323327X_1 + 3.046188X_2$$

1. R-squared

The calculation for the coefficient of determination (R-squared) for a multiple regression is the same as that used for simple regression. One issue of concern about the R-squared value in a multiple regression is that, as you add more variables, the R-squared value will always increase. This will happen

Stepwise Selection for CARRYOVER

Selection:Forward Maximum steps:500 F-to-enter: 4.00
Control: Manual Step: 2 F-to-remove: 4.00

R-squared:.64670 Adjusted:.62903 MSE:2.93785E13 d.f.:40

Variables in Model	Coeff.	F-Remove	Variables Not in Model	P.Corr.	F-Enter
FUNDS_REC	0.32333	8.1887	BILLINGS	.1544	.9529
BACKLOG	3.04619	67.4504	WIP	.1151	.5241

****

Model fitting results for: CARRYOVER

Variable	coefficient	std. error	t-value	sig.level
CONSTANT	9.983215E6	4.076106E6	2.4492	0.0188
FUNDS_REC	0.323327	0.112988	2.8616	0.0067
BACKLOG	3.046188	0.370906	8.2128	0.0000

R-SQ. (ADJ.)= 0.6290 MAE=4094121.070998

Stnd. Error of Est. = 5420195.090399

****

Analysis of Variance for the Full Regression

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-value
Model	2.15101E15	2	1.07551E15	36.6086	.0000
Error	1.17514E15	40	.93785E13		
Total Corr.	3.32615E15	42			

Figure 12. Stepwise Selection of Variables

regardless of the relationship between the independent variable and the dependent variable. An adjusted R-squared value takes care of this problem. The formula for an adjusted R-squared is the following :

$$\underline{R}^2 = 1 - (1 - R)^2 [(n - 1)/(n - k)]$$

Where: $\underline{R}$ = the corrected coefficient

R = the uncorrected coefficient

n = the number of observations, or sample size

k = the number of variables in the equation

It is possible for the adjusted R-squared to decline if the addition of another independent variable produces too small a reduction in $(1 - R^2)$ to compensate for the increase in (n-1)/(n-k). [Ref. 15:pp. 13-14] So the adjusted R-squared value of 62.90% is the truer measure of the strength of the multiple regression equation.

2. Error distribution

The regression equation $Y_c = a + bX$ can be used to calculate the expected value of Y_c. However, the expected value will differ from the actual value of Y. The actual value of Y is calculated from the equation $Y = a + bX + e$. The error terms (or residuals), e, represent

the differences between Y and Y_c. Analysis of the residuals is a crucial step in assessing the validity of a regression model. [Ref. 15:p. 25]

One simple method of analyzing the residuals is to examine a plot of the residuals. Figure 13 reports a

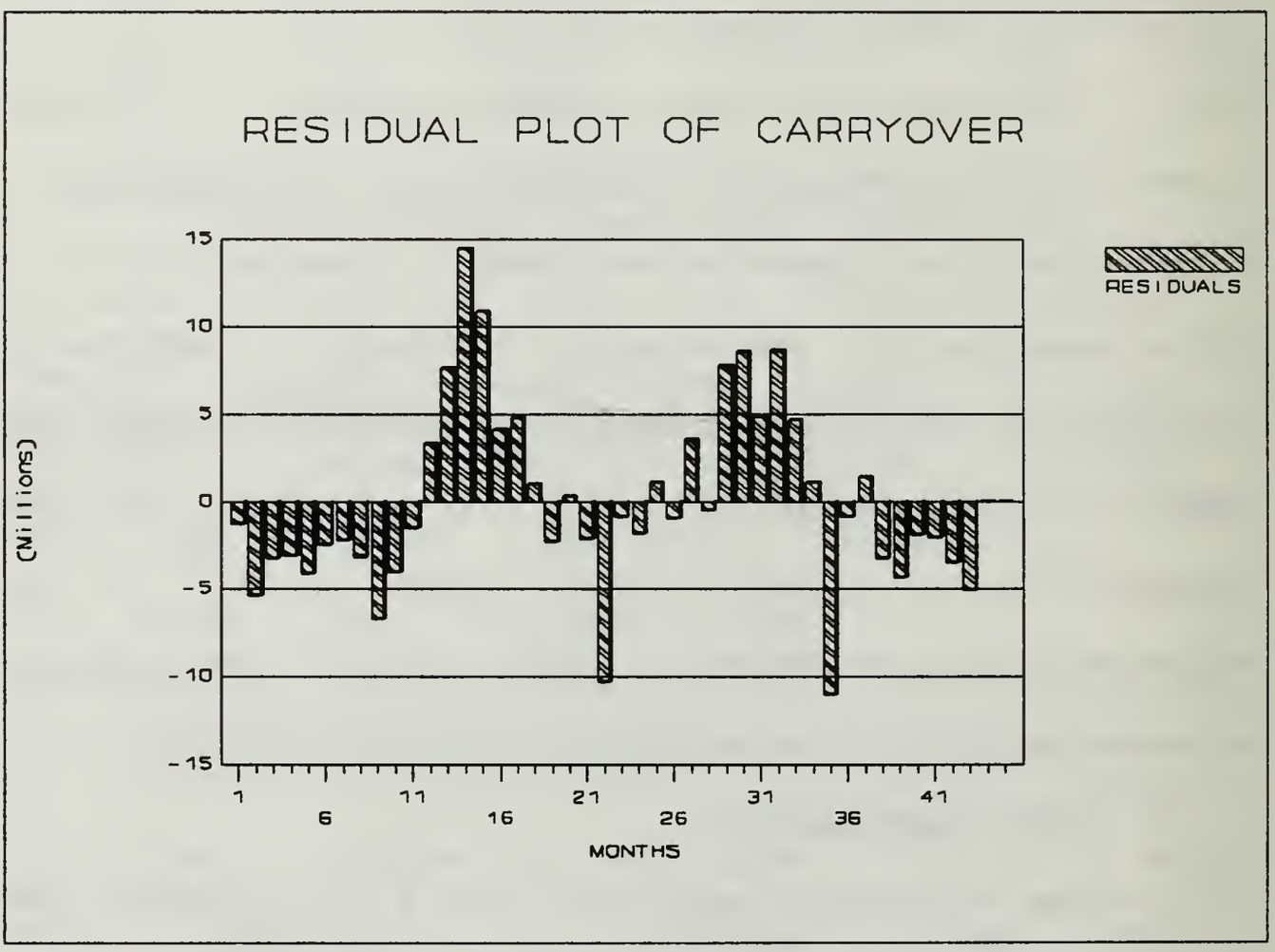

Figure 13. Residual Plot

plot of the residuals of the carryover equation. The residuals are plotted against time. A perfect plot of

the residuals would show values evenly above and below zero. The residuals of the carryover equation are above and below zero, but positive and negative residuals are grouped together in time bands. The plot shows that there might be a seasonal factor, however one of the underlying premise for this model is that seasonality is only a minor factor, so it was ignored. The author's assumption is that the model works but it may not be the best one.

3. Multicollinearity

In conducting a multiple regression one of the necessary conditions is that the independent variables are not perfectly related to each other in a linear fashion. The reason for the concern is that when two or more independent variables are correlated with one another it is not possible to disentangle the separate effects of each variable on the dependent variable. The best way to check for multicollinearity is to build a correlation matrix in which the simple correlation coefficient between every pair of variables is presented. [Ref. 15:p. 18] Table II shows the correlation matrix

for the carryover model. The rule of thumb is a simple correlation coefficient of more than about .7 between any

TABLE II

CORRELATION MATRIX FOR COEFFICIENT ESTIMATES

	CONSTANT	FUNDS RECEIVED	BACKLOG
CONSTANT	1.0000	-.4214	-.9063
FUNDS RECEIVED	-.4214	1.0000	.0565
BACKLOG	-.9063	.0565	1.0000

two explanatory variables can cause multicollinearity. In the carryover model we do not have this problem.

4. Summary

The best regression equation to estimate carryover is $Y = \$9,983,215 + 0.323327X_1 + 3.046188X_2$ with an adjusted R-squared value of 62.90%. X_1 is the variable "funds received-no lag". X_2 is the variable "backlog-two month lag". The 95% confidence interval for carryover is +/- 2 times ($5,420,195) or +/- $10,840,390. After analyzing the error terms (residuals) and checking for

multicollinearity the conclusion is that this is a good model.

D. TESTING THE MODEL

The proper way to assess the adequacy of a regression model is to test it. The method chosen to test the model was the following:

1. Run a multiple regression using only FY 85 to FY 87 data. Use only the independent variables "funds received-no lag" and "backlog-2 month lag".
2. Assume that the current time is the third month of FY 88. Three months of actual data for that year are available and it is necessary to forecast carryover for the next three months.
3. Estimates for funds received and backlog are based upon the manager's experience. The PWC manager has a reasonable idea of the amount of workload to be expected in the next several months. The estimates for backlog will have to be for five months in advance because of the lagged relationship.

4. The estimates are used in the regression equation. The predicted carryover is compared to the actual.

Figure 14 presents the multiple regression of FY 85 to FY 87. The adjusted R-squared is only 43.45%. This can be expected because fewer data points were used. The resultant equation is $Y = \$21,371,210 + 0.447402X_1 + 1.893256X_2$

Model fitting results for: CARRYOVER

Variable	coefficient	std. error	t-value	sig.level
CONSTANT	2.137121E7	5.552981E6	3.8486	0.0006
FUNDS RECEIVED	0.447402	0.126099	3.5480	0.0013
BACKLOG	1.893256	0.497228	3.8076	0.0006

R-SQ. (ADJ.)= 0.4345 MAE=3707267.864483

Stnd. Error of Est.= 5042254.977199

Figure 14. Multiple Regression of FY 85-87 Data

The following are actual data for FY 88 and the estimated values for the independent variables:

FY 88	ACTUAL FUNDS RECEIVED	BACKLOG
OCT	$37,873,333	$5,910,437
NOV	9,395,333	7,626,000
DEC	16,664,333	7,976,000

FY 88	ESTIMATED FUNDS RECEIVED	BACKLOG
JAN	$9,000,000	$7,000,000
FEB	11,000,000	7,200,000
MAR	8,500,000	6,800,000
APR		6,900,000
MAY		6,700,000

Using the estimated figures and the regression equation, the predicted carryover compared to the actual carryover for the months, January to March, is:

	PREDICTED	ACTUAL	PERCENT ERROR
JAN	38,271,969	$32,461,000	17.90%
FEB	39,356,098	33,444,000	17.68%
MAR	37,858,942	33,239,000	13.90%

The percent error is high but considering that the adjusted R-squared was 43% this is not an unexpected result. The carryover model has an adjusted R-squared of 62.9% so the percent error should be less. The other factor that will influence the accuracy of the model is

the accuracy of the PWC manager's estimates of the variables "funds received" and "backlog".

This model has some drawbacks. The percentage of error needs to be below ten, because the PWC manager has to control carryover within thousands of dollars. To develop a three month forecast of carryover the manager will have to predict funds received for three months and backlog for five months. It will be difficult for the manager to develop reliable predicted figures for backlog in the fourth and fifth month. The reason is that these estimates will be based upon the manager's judgements and experience and the further out in time the forecast the more error is placed into the estimate.

E. SUMMARY

Prior to the application of data analysis, the data required transformation to give it uniformity. WIP for FY 85 was estimated and recurring workload was added to FY 88 monthly data.

Simple regression was conducted with each independent variables: (1) funds received; (2) billings; (3) backlog;

and (4) WIP, against dependent variable--carryover. This process was repeated three more times by lagging each of the independent variables one, two, and three months.

Using the results of the four regression outputs, the variables selected to develop the model were funds received and billings with no lag. The best variables for billings and backlog were the variables with one and two month lag, respectively.

Stepwise regression was used to pick the variables for the model. The result from this procedure is the regression equation to estimate carryover is $Y = \$9,983,215 + 0.323327X_1 + 3.046188X_2$ with an adjusted R-squared value of 62.90%. X_1 is the variable "funds received-no lag". X_2 is the variable "backlog-two month lag". The 95% confidence interval for carryover is +/- 2 times ($5,420,195) or +/- $10,840,390. For example if the predicted carryover amount for a month was $35,000,000. The PWC manager can be 95% confident that the actual value of the carryover is between $24,159,610 and $45,840,390.

The model was tested by using only FY 85-87 data to develop a test model and then using that model to predict FY 88 data. The error rate for the test was between 12 and 18 percent. The results are inconclusive because the R-squared value for the test model was only 43% whereas it was 62.90% using all of the data (FY 85-88). But a valid assumption can be made that with a higher R-squared value the error rate should be lower.

V. CONCLUSION

A. RESEARCH RESULTS

Carryover will continue to be a scrutinized budget item because the current fiscal climate, emphasis on deficit reduction, is expected to continue for the next several years.

The objective of this research was the development of a statistical model for forecasting fund carryover. The hypothesis was that fund carryover is functionally related to backlog of work. This model should be able to forecast carryover four to six months in advance. The purpose of the model is to be used as a management tool for the Public Works Center (PWC).

The year-end carryover target figure is derived from negotiations between the individual PWC activity, NAVCOMPT and NAVFAC. The majority of carryover is composed of backlog. 95% of the dollar value of this backlog is specific maintenance work. This backlog is composed of year-end dump or older work that was year-end dump from prior years.

The model was developed using monthly historical data from FY 85 to FY 88 for the following variables: (1) funds received; (2) billings; (3) backlog; (4) WIP; (5) and carryover. A portion of the data required transformation to give it uniformity.

Simple, multiple and stepwise regression methods were applied. Also, an examination was performed on whether there might be a lagged relationship between the dependent and independent variables. The outcome of these analyses was a model that uses independent variables "funds received-no lag", X_1, and "backlog-two month lag", X_2. The prediction equation is $Y = \$9,983,215 + 0.323327X_1 + 3.046188X_2$ with an adjusted R-squared value of 62.90%. The 95% confidence interval for carryover is: +/- 2 times ($5,420,195) or +/- $10,840,390.

B. RESEARCH CONCLUSIONS

The PWCs cannot use two methods to reduce the backlog: (1) temporarily reject new requests for services; (2) hire more in-house personnel to finish more jobs (ceiling constraints). One management tool the PWCs do have is to effectively use contracting services, Direct Cite Funding.

In conjunction with this the PWCs must continue to streamline the contracting process so the customer's service is timely and they must work closer with the customer earlier in the fiscal year to plan execution of major repair and maintenance projects. Factors in determining the carryover goal target should be: what is the nature of work within the backlog, in-house versus contract; and what time constraints, outside the activity control, are imposed upon the activity in the contracting process.

The forecasting model developed is not a perfect one. Some of the problems with the model can be attributed to the inaccuracies in the historical data. The PWC can use the model as a check against their own estimates for carryover. This model can reliably forecast only up to three months in advance. Additionally, it is applicable only at PWC Pearl Harbor Hawaii. A customized model would have to be developed for the other PWCs using each PWC's historical data.

C. RECOMMENDATIONS FOR FUTURE RESEARCH

This research can be expanded by developing forecasting models for several PWCs and comparing the models. There are

maybe some elements that are common to each model. A universal core model could be developed.

The analysis of the historical data can be expanded. The seasonality of the residuals could be explored in detail. Also, a distributed lag regression model could be applied and compared to a stepwise regression model. Other independent variables should be considered, such as contract workload. Several alternate methods could be applied to selected the independent variables. Plausibility is a very powerful explanatory method.

A study should be done to determine what is the proper amount of backlog for a PWC and what is the best way to come up with the year-end carryover target figure.

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